EFFECT OF AGRO-ECOLOGICAL ZONE AND STORAGE ENVIRONMENT ON THE QUALITY OF THE PHYSIC NUT *(JATROPHA CURCAS)* SEED

C. Y. Akai[1], N. S. Olympio[1] and G. Nyarko[2]
[1]Department of Horticulture, Faculty of Agriculture,
Kwame Nkrumah University of Science and Technology, Kumasi and
[2]Department of Horticulture, Faculty of Agriculture,
University for Development Studies, Tamale.

ABSTRACT

Jatropha curcas seeds were harvested at brown ripe stage from plants growing in the Guinea Savannah (GSZ), Forest (FZ) and Coastal Savannah (CSZ) Zones in Ghana and were assessed for seed quality at harvest, after seed drying and seed storage. The harvested seeds were dried to 8 and 10 % moisture levels and subjected to two storage conditions from March to August, 2007. The principal aim of the experiment was to evaluate the effect of storage on the quality of J. curcas seed. Some of the seed characteristics assessed were: seed kernel to shell ratio, thousand seed weight (TSW), seed oil content, percentage seed germination, seedling dry weight, seed vigour index, and fungi associated with the seed. There were no differences in the seeds from the three zones in terms of seed oil content, percentage seed germination, seedling dry weight and seed kernel to shell ratio at harvest. However, seed from the FZ showed superior performance in absolute terms for most of the parameters measured. After drying, seed from FZ at both 8and 10 % seed moisture had highest TSW, seed oil content, percentage germination and vigour index. The result further indicated that even though cold storage seemingly preserved J. curcas seed better than room storage, it rather promoted fungi survival on the seed. The results suggest that fresh seed of Jatropha from any of the three zones could be used for planting with satisfactory germination and seedling establishment.

INTRODUCTION

Physic nut (*Jatropha cucas*) belongs to the family Euphorbiaceae L (Dokosi, 1998). Its origin has been disputed but many authors reported that it is native to Central America and Mexico from where it spread to Africa and Asia by Portuguese seafarers (Francis *et al.*, 2005). Jatropha is pollinated by insects and fruit initiation, development and maturation take nine weeks. The resultant trilocular ellipsoidal fruit is green but turns yellow on maturity. The fruit contains three black seeds which averagely measure 18 mm long, 10 mm wide and the thousand seed weight is about 727 g (Benge, 2006).

Dokosi (1998) reported that the plant, aside its medicinal uses, has been cultivation in Ghana for centuries as a hedge, a boarder plant or for its aesthetic value. In Mali, a good number of local women are currently gainfully employed in cottage industry through the extraction and use of the seed oil for household energy and soap making (Heller, 1996). Earlier in the 1900s, Jatropha oil was produced on commercial basis and exported from Cape Verde to Lisbon and Marseille for soap and cosmetic manufacture (Heller, 1996). Yield records reported for Jatropha in Ghana are comparable with world figures ranging between 4 - 8 tons/ha (Ghana Energy Commission, 2005).

Since the oil crisis in the 1970s coupled with the limited world oil resources, most crude oil importing countries (including Ghana) have been trying to develop alternative sources of energy from vegetable materials to meet domestic needs, and *J. curcas* has been found to be very promising (Oladimeji, 2007). Between 2001 and 2004, crude oil imported into Ghana ranged between US $516.8 and US $ 816.1 and had hit US $ 1.3 billion in 2007 with a great negative effect on Ghana's GDP (Ghana Energy Commission, 2005).

It is likely that Jathropha cultivation in Ghana could reduce the import bills and also safeguard fuel security of the state.

It is reported that Jatropha seed oil has insecticidal properties (Makkar *et al.*, 2004) which when properly utilized can help reduce postharvest losses in grains and seeds due to insects. The fact remains undisputed that postharvest losses bedevil the agricultural world leading to huge food supply deficits. van Gastel *et al.* (1996), reported that crop losses resulting from initial poor quality seed and storage conditions stood at 30 % world-wide. Jelle (1992), also, indicated that between 25 - 40 % agricultural products including seeds are lost yearly due to storage pests and diseases.

Despite these numerous benefits and potentials outlined, a number of challenges still militate against the production of Jatropha in Ghana. Key to this is the non-availability of high quality Jatropha seed and little information from research on quality seed production and postharvest handling. This attests to report by the Adventist Development and Relief Agency (ADRA) that farmers in Ghana failed to establish Jatropha plantations due to poor quality seed and postharvest handling including storage (ADRA, 2004). The study was, therefore, undertaken to assess the seed quality and storage potential of the physic nut seeds collected from three major agroecological zones, namely the Guinea Savannah Zone (GSZ), Forest Zone (FZ) and Coastal Savannah Zone (CSZ) in Ghana.

MATERIALS AND METHODS

Seed collection and processing: *Jatropha curcas* fruits were harvested per zone from the GSZ, FZ and CSZ between January to February from plants of different ages at brown ripe stage and the seeds manually extracted from one thousand six hundred fruits. The seeds were air-dried on a concrete floor in a room with open sides covered with wire net for two weeks and further dried to 8 and 10 % moisture content using humidified dryer (Petkus Man. Co.). Four hundred (400) seeds from each of the two moisture levels were picked and placed into 200 µm white transparent polythene bags, sealed (Sinnadurai, 1992) and stored from March to August either in an airy room (24-35°C, 72-96 % RH) and cold store (10-15 °C and 90 % RH) conditions. The Polythene bags were replicated to cater for all tests.

Location and site of experiment: Seeds for the experiment were stored in the seed storage at Asuoyeboah (cold store) and the airy room (ambient conditions) at the Department of Horticulture, Kwame Nkrumah University of Science and Technology, Kumasi under the conditions as stated. Kumasi is on Latitude + 06717 and Longitude - 001600 (www.Trip Advisor.com, 2007). The area experiences bimodal rainfall (Dickson and Benneh, 1970).

Seed assessment: One hundred and fifty seeds were drawn from the polythene bags of each of the two storage conditions and tested for seed quality. The following parameters were assessed:

Germination test: Fifty (50) seeds were sown in a 35 cm diameter clay pan containing 3.6 kg sterilized soil mixture comprising one part top soil and one part river sand (Ginwal *et al.*, 2005). The experiment was replicated three times and the pans were placed in the plant house. The soil was kept moist and germinating seedlings were brought out of the plant house and exposed to full sunlight from the 5th day after sowing till the 14th day. Percentage germination was calculated based on normal seedlings (ISTA, 1979). This test was repeated monthly for six consecutive months.

Seedling dry weight and vigour test: On the 14th day, seedlings were gently removed from the clay pans, roots washed and oven dried at 105 °C for 17 hours as recommended by Agrawal (1995). Dry weight of seedlings was recorded after cooling for 30 minutes. This assessment was repeated monthly for the six months of seed storage.

Thousand seed weight: Hundred (100) seeds in eight replications were drawn per each location and the variance calculated by, Variance = $N(\acute{O}X^2) - (\acute{O}X)^2 / N(N-1)$, where N = Number of replicates, X = weight of each replicate in grams. The standards deviation (S) was computed by S = "Variance and Coefficient of variation = $S/\mu \times 100$, where μ = mean weight of 100 seeds. From the above, the average weight of

1000 seeds was calculated from the formula, (10 × μ), as suggested by ISTA (2007).

Seed kernel to shell ratio: Hundred (100) seeds in five replications per each location were weighed, cracked and the kernel and shell weights measured separately. The ratio between the kernel and shell weights was computed.

Seed oil content: Samples of seed (100) were drawn from the GSZ, FZ and CSZ before and after storage and the oil content determined by the Kedjahl Oil (Ether) Extraction Method.

Fungi identification: The blotter method was used to identify the Fungi associated with the seeds. Ten seeds per Petri dish lined with a well soaked three filter papers and incubated for 7 days at 22 °C under 12 hours of alternating cycles of light and darkness (ISTA, 2003). This was repeated twenty times (200 seeds). On the 7th day, the seeds were examined under compound and stereomicroscopes and the different fungi species identified and recorded.

Statistical analysis: All the parameters determined above were recorded and data subjected to ANOVA and T-test using Genstat Statistical package.

RESULTS AND DISCUSSION

Seed oil content

J. curcas stores its oil in the cotyledon like oil palm (*Elieas guineensis*) or soyabean (*glycine max*) (Tweneboah, 2000). The seed oil content of *J.curcas* is generally ranges between 35 and 55 % (Heller, 1996; Krishnamurthy, 2005). Seed oil content obtained in this experiment was generally high and this could be due to the slow and low drying temperature of the humidified dryer as reported by Sastry *et al.* (2007). Oil content determined at 8 and 10 % moisture levels showed variability ($p > 0.05$) among the jatropha seeds collected from the three agroecological zones (Table 1). Before storage, seeds from the FZ dried to 8 % moisture level gave the highest seed oil content (55.92 %). After storage, seeds from the FZ dried to 10 % and stored in the room yielded the highest percentage oil content (56.59 %) followed by seeds from the CSZ and the GSZ. The higher seed oil content from the FZ could be attributed to bigger cotyledons/seed weight confirming the direct correlation between seed kernel weight and seed oil content (Tweneboah, 2000; Bankole *et al.*, 2005). It further emphasizes, that improvement in the size of the cotyledon could lead to increased seed oil yield (Fortescu and Turner, 2007). Seeds under cold storage were generally low in oil content and this may be due to the activities of the fungi which survived the drying temperature of the humidified dryer (Hartmann *et al.*, 1990). Oil content dropped when seeds from the GSZ and CSZ were dried to 10 % (cold storage) and 8 % (room storage) moisture levels respectively, which suggests a critical temperature consideration when drying seeds from the two zones for oil extraction. This means that several factors, including storage

Table 1. *J. curcas* seed oil content before and after 6 months cold and room storage conditions across ecological zones in 2007.

		Percentage seed oil content		
Seed source	Seed Moisture Content (%)	Before storage	Room Storage for six months	Cold Storage for six months
Coastal Sav. Zone	8	42.65	43.40	36.50
Coastal Sav. Zone	10	53.44	41.40	44.10
Forest Zone	8	55.92	50.10	53.43
Forest Zone	10	54.64	50.30	56.59
Guinea Sav. Zone	8	48.40	45.40	47
Guinea Sav. Zone	10	54.14	50.71	43.30

SED = 2.10
t – tab = 2.18.

Table 2. *Jatropha curcas* seed kernel to shell ratio and thousand seed weight across zones dried to two moisture content in 2007

Zone of seed collection	Seed moisture content(%)	K: S ratio	1000 seed weight (g)
Coastal Savannah Zone	8	0.57	650.8
Coastal Savannah Zone	10	0.51	651.5
Forest Zone	8	0.59	702.3
Forest Zone	10	0.53	690.9
Guinea Savannah Zone	8	0.57	572.1
Guinea Savannah Zone	10	0.57	501.3
LSD+ 5%		0.08	17.1
CV%		16.3	1.6

conditions, seed moisture content, packaging and drying temperature could affect seed oil content as has already been reported by Simic *et al.* (2007).

Seed kernel to shell ratio and thousand seed weight

Seed kernel to shell ratios (K:S) and thousand seed weight (TSW) are shown in Table 2. Though K:S ratios across ecological zones were not statistically different ($P > 0.05$), seeds from the FZ had the highest K:S ratio when dried to 8 % moisture level. This means that environmental influence on seed shell formation is the same for the three agroecological zones.). This finding is not different in terms of K : S ratio to the result obtained by Heller (1996) and Gardner *et al.* (1985).

TSW was statistically different ($p < 0.05$) and ranged from 572.1 g to 702.3 g (Table 2). Seed from FZ at 8 % produced the highest thousand seed weight (TSW). Generally, seeds from the FZ weighed heavier than those from the other two zones and may be attributed to the different environmental factors prevailing in the different agroecological zones of seed collection (Gardner *et al.*, 1985). The average weight recorded in this study was, however, divergent from that of Benge (2006) who reported of higher seed weight of 727g.

Seedling dry weight

J. curcas seed vigour was determined by measuring seedling dry weight for six months while the seeds were in cold and ambient room storage (Figures 1 and 2). Seedling dry weight increased sharply in the second month, going higher in the third month, irrespective of the ecological zones and the moisture content levels at which the seeds were stored. This meant that seed vigour was low at harvest but increased to peak in the third month after harvest. This indicated that the *J. curcas* seed was probably under dormancy for the first two months after harvest as suggested Gardner *et al.* (1985). In the third month after harvest, seeds from the CSZ had the highest vigour among the seeds collected from the three zones irrespective of the storage conditions (Figures 1 and 2). Seed vigour, however, decreased drastically in the fourth month except for seeds from the FZ which decreased rather in the fifth month as indicated by the seedling dry weight (Figures 1 and 2). Although seeds from the CSZ were more vigorous, those from the FZ have the propensity to store longer than seeds from the GSZ and CSZ. The decrease in seed vigour thereafter continued gradually to the sixth month. This means *J. curcas* seeds can store for six months and still maintain germination. Vigour of seeds, from the ecological zones, significantly differed ($P < 0.05$) in the third, fifth and sixth months of seed storage (Figures 1 and 2). Seeds stored under ambient room conditions recorded higher seed vigour during the fifth and sixth months than those stored under cold conditions. This could be attributed to the fact that the cold storage conditions may have been more conducive for the survival of the fungi which affected the seed vigour.

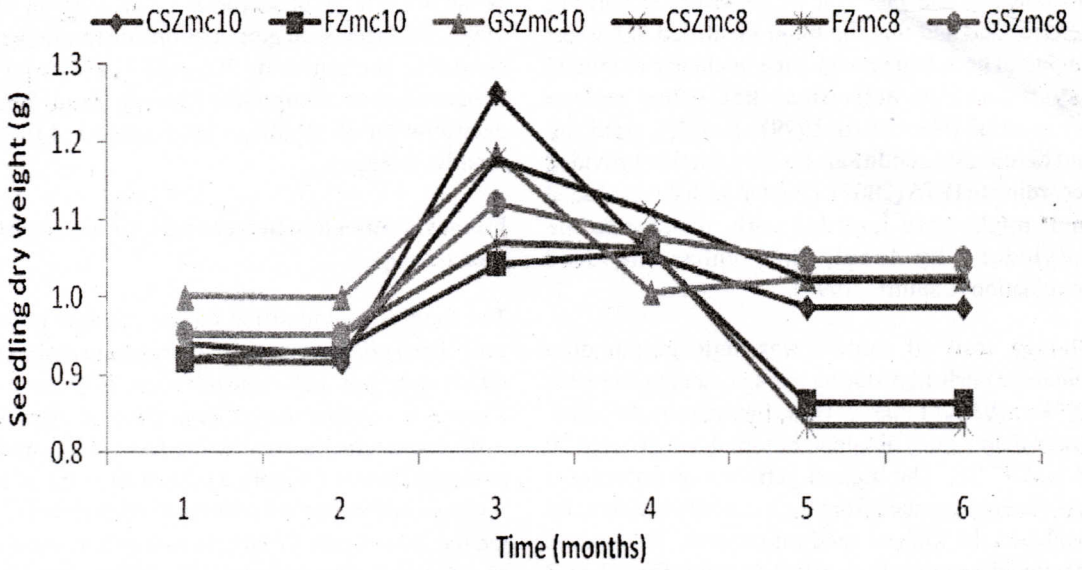

Figure 1: Effect of room storage on *J. curcas* seedling dry weight across ecological zones and moisture contents in 2007.

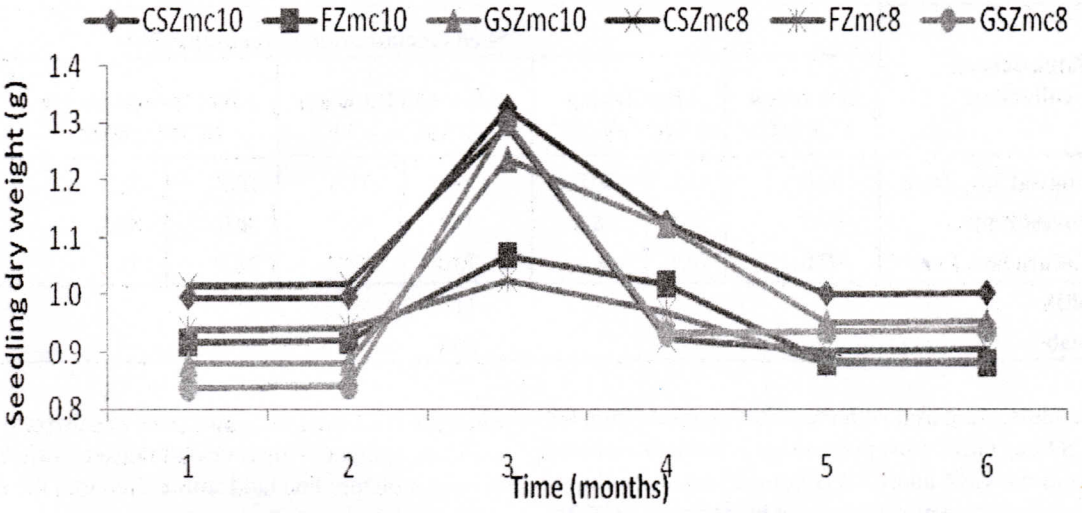

Figure 2: Effect of cold storage on *Jatropha curcas* seedling dry weight across ecological zones and moisture contents in 2007.

Percentage seed germination

Germination of *J. curcas* seeds generally decreased after drying and storage, however, seed from the FZ, comparably, had higher values in percent germination (Table 3). *J.curcas* seed exhibited epigeal germination as described by Gardner *et al.*, (1985) and Hadidi (1996). Collection zone did not significantly affect germination of seed tested soon after harvest ($p < 0.05$). This means that freshly harvested uninfected seed will germinate equally well irrespective of the zone of seed collection. The high percentage germination observed at harvest may be

attributed to the fact that the seed tested had not deteriorated and that the fungi identified at harvest might not have had enough time or chance to initiate any metabolic activities that often reduce germination (Neergaard, 1979). Besides, good soil and favourable conditions for germination provided according to ISTA (2007), coupled with the hard seed shell might have impeded early damage to the cotyledons by fungi, thus enhancing seed germination (Cantliffe, 1998).

Though seed oil content was high, germination remained fairly high during storage, ranging between 68 % and 93 % (Table 3). These figures were, however, lower than values obtained before drying (range 90 % and 97 %). The highest germination percentage was observed in seed from the FZ which incidentally produced the highest seed oil content. This means that invading microflora effect on seeds from the FZ was less compared with the effect on seeds from the CSZ and GSZ. Low percentage germination of seed from the GSZ and CSZ (Figure 3) could be due to fungi infection as was reported by Neergaard (1979).

Drying the seed to 10 % and 8 % moisture levels resulted in differences in germination ($p < 0.05$). Higher mean germination percentage was obtained by seed from the FZ at 10 % (Table 3) despite the significant presence of *Aspergillus flavus, Fusarium oxysporium* and *Cladosporium sphaerospermum* etc. (Figures 4a and b). This could be attributed to reduce degenerative effect of the pathogenic fungi and also implied that drying the Jatropha seeds to 10 % or 8 % did not kill the observed fungi (Hartmann *et al.*, 1990). Reduced seed germination due to storage was similar to the report by Kwoseh (1994) who had observed that xerophytic storage fungi caused deterioration of soyabean seed subjected to three months storage.

Fungi identification before and after six months of seed storage

Ten fungi were identified before storage, however only *Aspergillus flavus (Af), Curvularia lunata (Cl), Cladosporium sphaerospermum (Clados),* and *Fusarium oxysporium (Foxy)* showed significant differences among treatments ($p < 0.05$) and are presented below (Figure 3). Seed from FZ at 10 % moisture had higher infection level of *A. flavus* (2.77). On the other hand, *Cladosporium sphaerospermum* (1.44) and *F. oxysporium* (1.65) levels were highest when the seed from the same zone was dried to 8 % moisture content. This revealed thatseed dried to 8 % seed moisture leveland stored favoured the fungi survival. Germination percentage, however, remained fairly high (between 68.3 % and 93.3 %, Table 3), despite the significant presence of the fungi (Figure 4a and b). This could be attributed to reduce degenerative effect of the identified fungi. It could also imply that drying *J. curcas* seed to 10 % or 8 % did not kill the observed fungi (Hartmann *et al.*, 1990). Seed germination, however, fell below what was obtained at the initial test (Table 3). Kwoseh (1994) had observed that xerophytic storage fungi caused deterioration of soyabean seed when it was

Table 3: Percentage seed germination of *J. curcas* from the three ecological zones as affected by drying and storage (2007)

Zone of seed collection	Seed Germination percentage (%)						
	At harvest 17.5 MC	After drying 10 MC	8 MC	After Cold storage 10 MC	8 MC	After Room storage 10 MC	8MC
Coastal Sav. Zone	90.0	68.3	69.8	75.3	73.3	78.7	72.7
Forest Zone	97.0	90.7	88.3	93.3	90.7	86.0	87.3
Guinea Sav, Zone	92.0	70.3	68.8	72.0	72.7	78.7	72.7
SED				11.01			
t-tab				2.14			

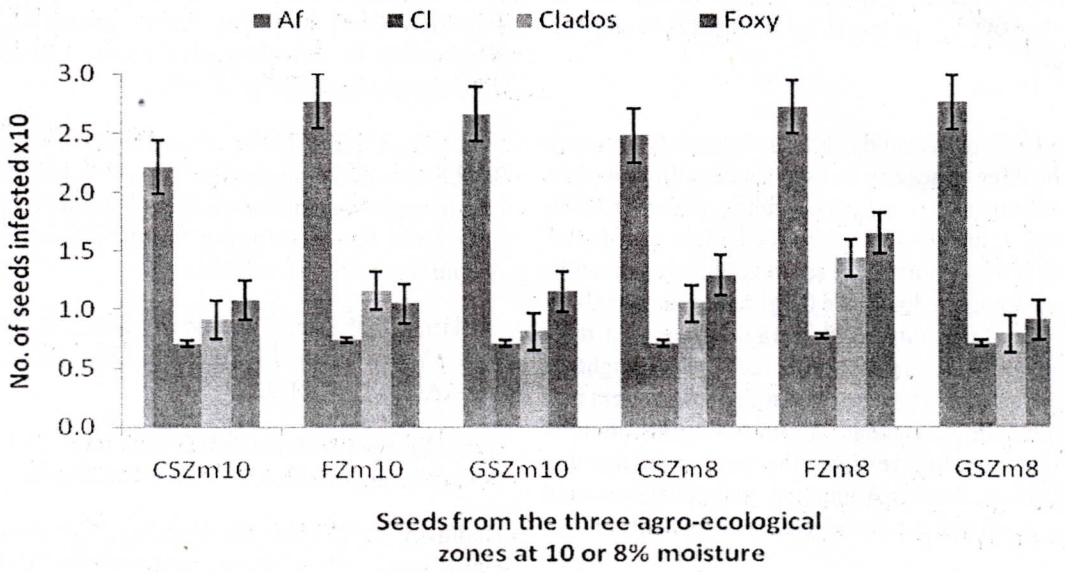

Figure 3. Effect of drying on fungi survival on *J. curcas* seed—2007

- Af = *Aspergillus flavus*, Cl = *Curvularia lunata*, Clados = *Cladosporium sphaerospermum* and Foxy = *Fusarium oxysporium*

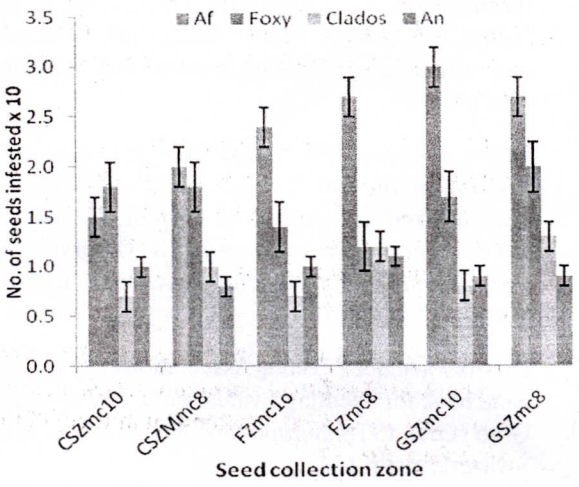

Figure 4a. Effect of cold storage on fungi survival

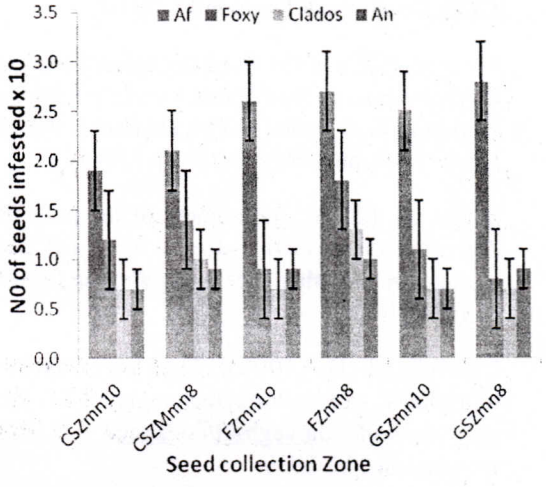

Figure 4b. Effect of room storage on fungi survival

stored for three months. In the current project, four important fungi identified after seed storage are indicated in Figures 4a and 4b. Seed from GSZ store under cold conditions showed higher infestation levels for *Aspergillus flavus* (3.0), *Fusarium oxysporium* and *Cladosporium sphaerospermum*. There were significant differences among treatments ($p < 0.05$). It was observed that *Aspergillus niger* was not on any of the seed after storage, whereas, *Fusarium moniliforme, Fusarium subglutinans, Myrothecium verrucaria, Rhizopus* sp and *Colletotrichum dermatium* were recorded only after

storage. This implies that storage promoted the survival of the later four fungi (Figures 3, 4a and 4b).

Conclusion

Results from this study showed that seeds from any of the three zones can be used successfully for plant establishment at brown-ripe maturity. However, when storage is intended *J. curcas* seed might store better at 10 % seed moisture level in cold storage than in room storage. Though the fungi survived under both storage conditions, cold storage promoted their survival better than room storage which might be responsible for the decrease in seed oil content and germination percentage. From the results, there is still the need to investigate the best harvest age that will enhance seed germination, maintain vigour and storage life and expressed maximum seed oil content.

REFERENCES

ADRA, Adventist Relief Agency, (2004). Cultivation of physic nut to produce bio-diesel to mitigate climate change in Ghana. Ghana Education Fund (GEF), Small Grants Programme. Pp 1-4.

Agrawal, P. K. (1995). Seed storage and packaging. In. *Techniques in Seed Science and Technology,* 2nd Edition. P. K. Agrawal and M. Dadlani (Eds). South Asians Publishers, New Delhi. Pp 159- 163.

Benge, M. (2006). Assessment of the potential of *Jatropha curcas* (Bio-diesel tree) for energy production and other uses in developing Countries. ECHO website.

Cantliffe, J. D. (1998). Seed germination for transplants. *Horticulture Technology* 8 (4) Pp 1-5. www.imok.ufl.edu/veghort/docs/seed_072502a.pdf accessed on 24/7/2010.

Dokosi, O. B. (1998). *Herbs of Ghana.* Ghana Universities Press, Accra, Ghana. Pp 34.

Dickson, K. B. and Benneh G, (1970). *A new Geography of Ghana*, 3rd Edition. Longmans Group Ltd., London. Pp170.

Francis, G., Edinger R. and Becker K. (2005). Concept for simultaneous wasteland reclamation, fuel production, and socio-economic development in degraded areas in India: Need, potential and perspectives of *Jatropha* plantations, University Hohenheim, Germany Pp 22—35.

Fortescue, A. J. and Turner, W. D. (2007). Changes in Seed Size and Oil accumulation in *Brassica napus* L.by manipulating the source-sink ratio and excluding light from the developing siliques. *Australian Journal of Agricultural Research.*

Gardner, P. F., Pearce, B. R., and Mitchell, L. R. (1985). *Physiology of Crop Plants*, Iowa State University Press. AMES. Pp 221-225.

Ghana Energy Commission National (2005). Bio-Fuel Policy Recommendation, 2005 GEC Reports, Pp11-13.

Hadidi A. N. (1996). *Ecology Seed Germination Physiology*. In. Seed Science and Technology, Proceedings of a Train-the-Trainer workshop sponsored by Med-Campus Programme, (EEC) 24 April to 9 May 1993, Amman, Jordan. ICARDA, Aleppo, Syria. Vii +311 Pp77.

Hartmann, H. T.; Kester, D. E.; Genevene, R. and Davies, F. E. (1990). *Plant Propagation, Principles and Practices.* 5th Edition, Prentice-Hall Inc., New Jersey Pp. 35.

Heller, J. (1996). Physic Nut *(Jatropha curcas L).* Promoting the conservation and utilization of underutilized and neglected crops.1, Institute of plant genetics and crop research, Gaterslenben, International Plant Genetic Resources Institute. Rome. Pp 7-18; 35-37:43.

International Seed Testing Association (1979). ISTA hand book for Seedling Evaluation. J. Bekendam, R. Grob (Eds). ISTA Germination Committee. Zürich, Switzerland. Pp 4- 7.

International Seed Testing Association, (2007). International Rules for Seed Testing, Rules 1993., 2007 Edition, Zürich, Switzerland Chapter 5 Pp 1, Chapter 7 Pp 1.

Jelle, H. (1982). The storage of Agricultural products. AGROMISA Foundation. Tropical Agricultural Products. Wageningen, Netherland. Pp4.

Kwoseh, K. C. (1994). Quality of *Ocimum gratissimum* treated soyabean seeds under different storage conditions. MSc thesis, Faculty of Agriculture, University of Science and Technology, Kumasi.. Pp 69-77.

Krishnankutty, N. (2005). Differential rooting and sprouting behaviour of two *Jatropha* species and associated physiological and biological changes. *Current Science* .89 (6):Pp 1-10

Neergaard, P. (1979). *Seed Pathology* Vol.1, The Macmillan Press Ltd, London and Basingstoke, UK. Pp 285-288.

Sastry, D. V. S. S. R., Uppaduyaya, H. D. and Gowda, C. L. L. (2007). Influence of seed size in chickpea on moisture content during seed drying. ICRISAT, Patancheru 502 324, Andhra Pradesh, India. *Journal. icrisat.org.* Vol.3 (1).

Simic, B., Popovic, R., Sudaric, A., Rozman, V., Kalinovic, I. and Cosic, J. (2007). Influence of storage condition on seed oil content of maize, soybean and sunflower. *CCS Agriculture Conspectus Scienticus.*72 (3): 211-213.

Sinnadurai, S. (1992). *Vegetable Cultivation*. Asempa Publishers. Accra. Pp.47-49.

Tweneboah, K. C. (2000). *Modern Agriculture in the Tropics with Special Reference to West Africa Cash Crops*. CO-Wood Publishers, Accra- Pp114- 143.

van Gastel, A. J. G., Pognaotta, M. A. and Porceddu, E. (1996). *Seed Science and Technology*. International Center for Agricultural Research in the Drier Areas. Aleppo, Syria. Pp 268.